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(54) **SYSTEMS AND METHODS FOR SPRAYING AN AEROSOL**

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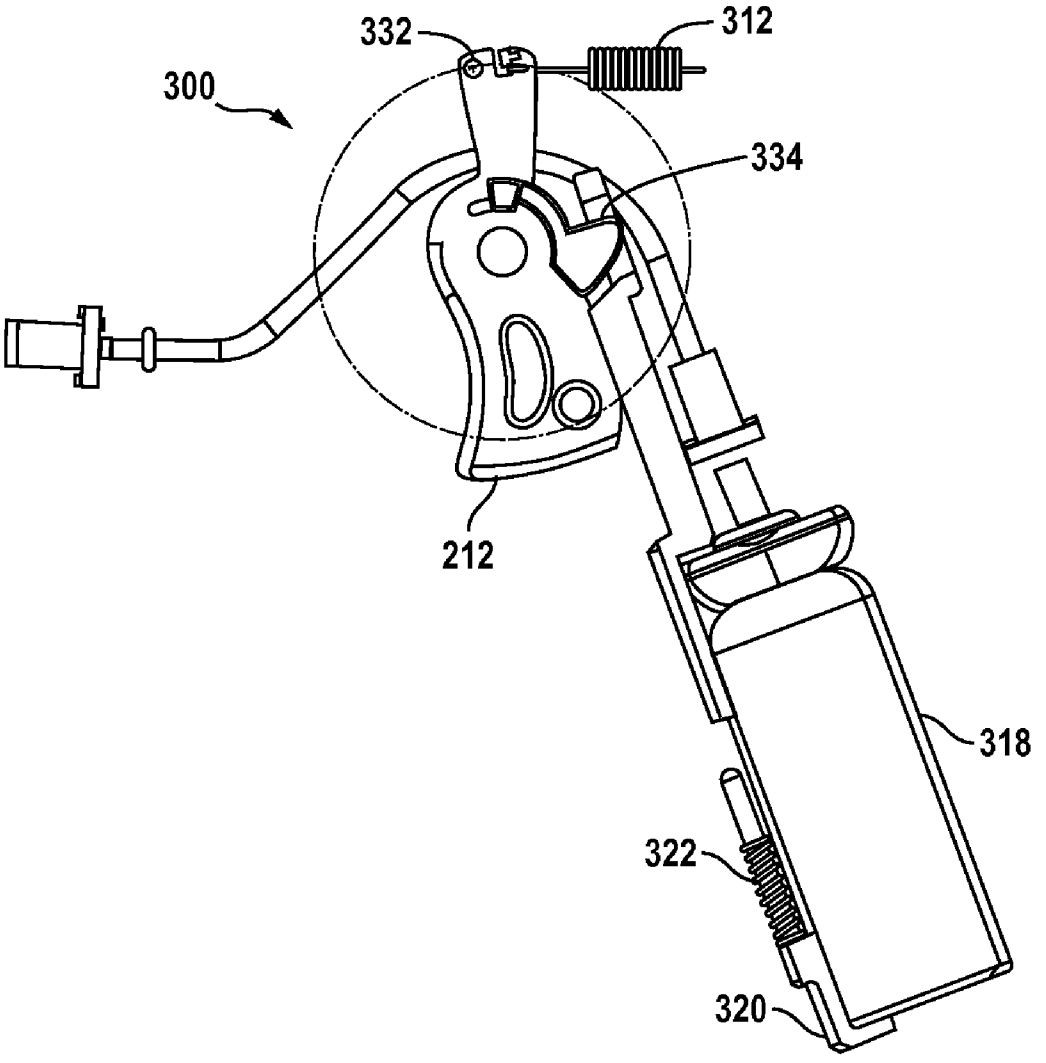
(57) **ABSTRACT**

A system for spraying, according to various aspects of the present invention, includes a shuttle and a trigger switch. The shuttle and the trigger switch cooperate with discontinuous mechanical coupling. The trigger switch provides a discontinuity in bias against operation of the trigger switch by the user. Consequently, the user experiences tactile feedback before spray is released. Prior to tactile feedback, the system establishes a communication link. When spray is released, the system transmits a notice via the communication link. Such a system when equipped with pepper spray aerosol is advantageous for self-defense.



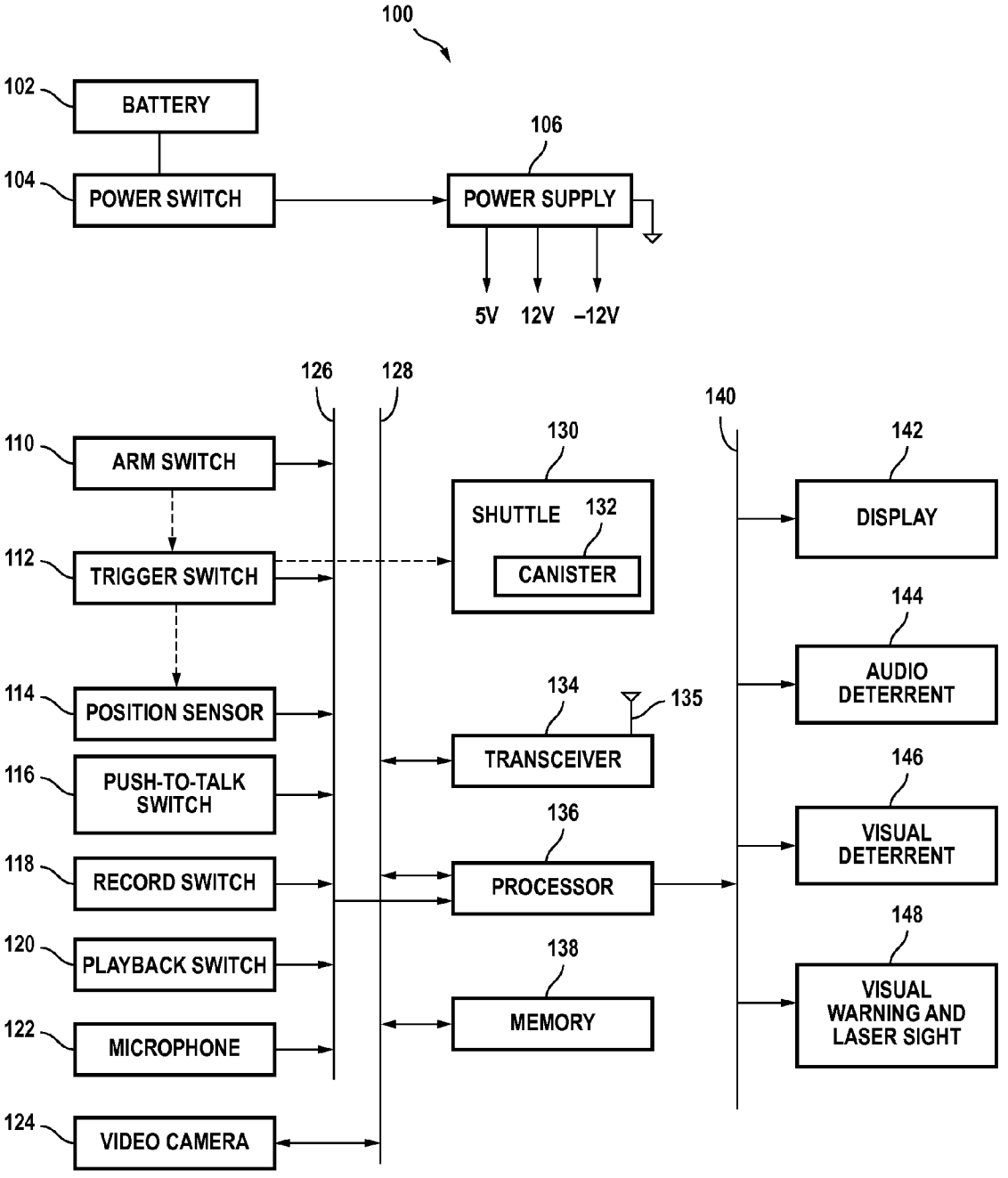

100
102
BATTERY
104
POWER SWITCH
106
POWER SUPPLY
5V
12V
–12V
126
128
140
110
ARM SWITCH
112
TRIGGER SWITCH
114
POSITION SENSOR
116
PUSH-TO-TALK SWITCH
118
RECORD SWITCH
120
PLAYBACK SWITCH
122
MICROPHONE
124
VIDEO CAMERA
130
SHUTTLE
132
CANISTER
134
135
TRANSCEIVER
136
PROCESSOR
138
MEMORY
142
DISPLAY
144
AUDIO DETERRENT
146
VISUAL DETERRENT
148
VISUAL WARNING AND LASER SIGHT

FIG. 1

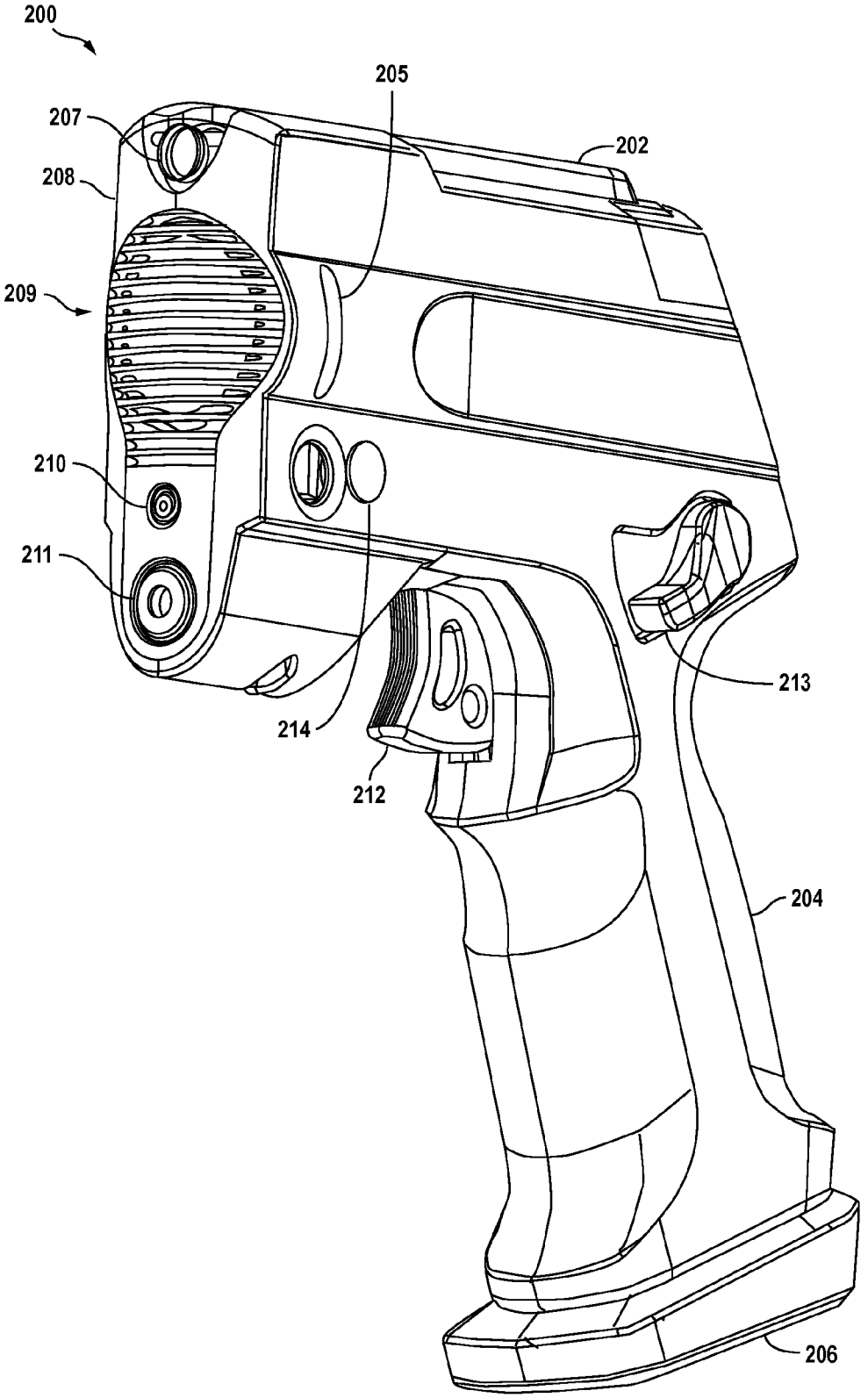


FIG. 2A

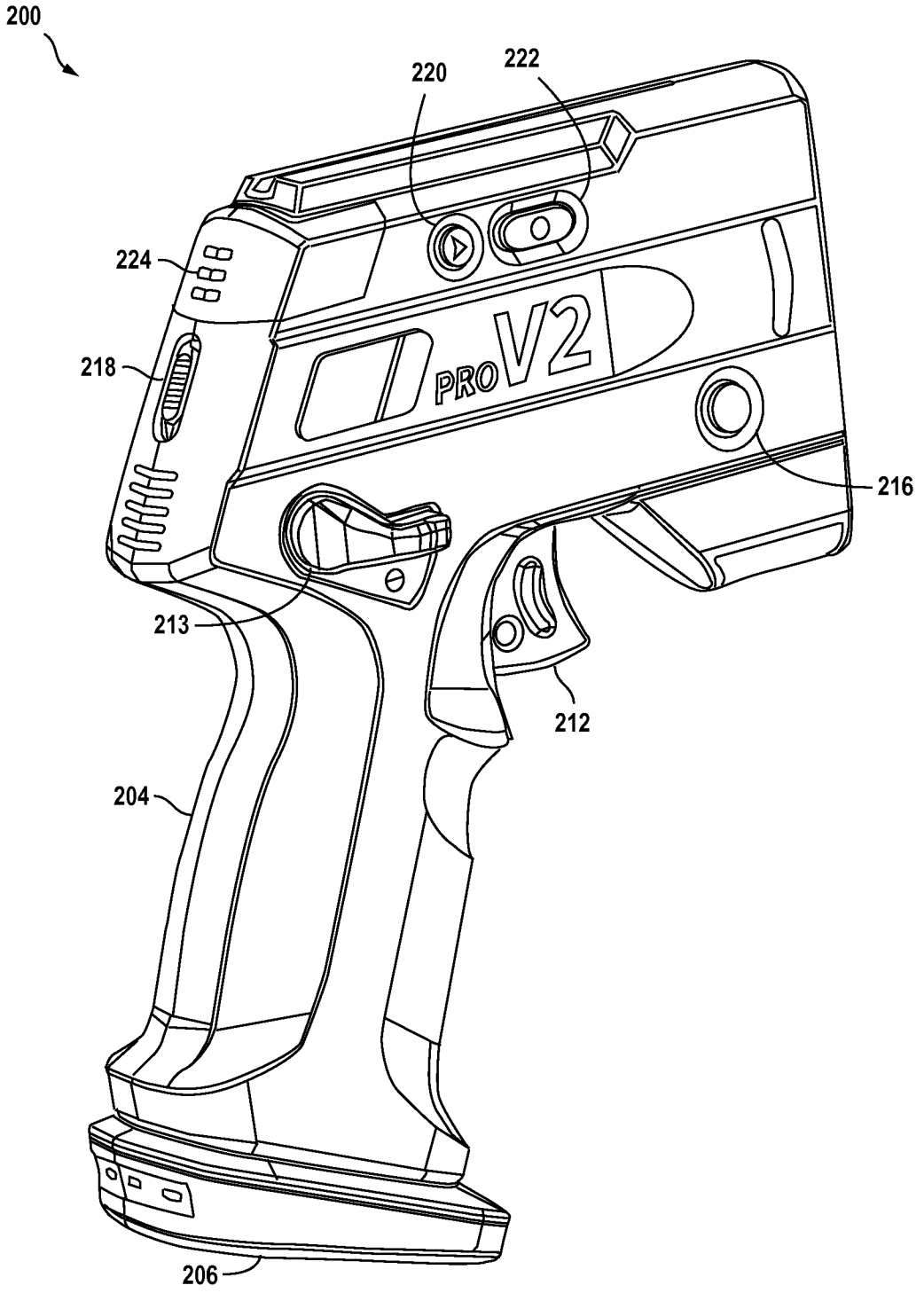


FIG. 2B

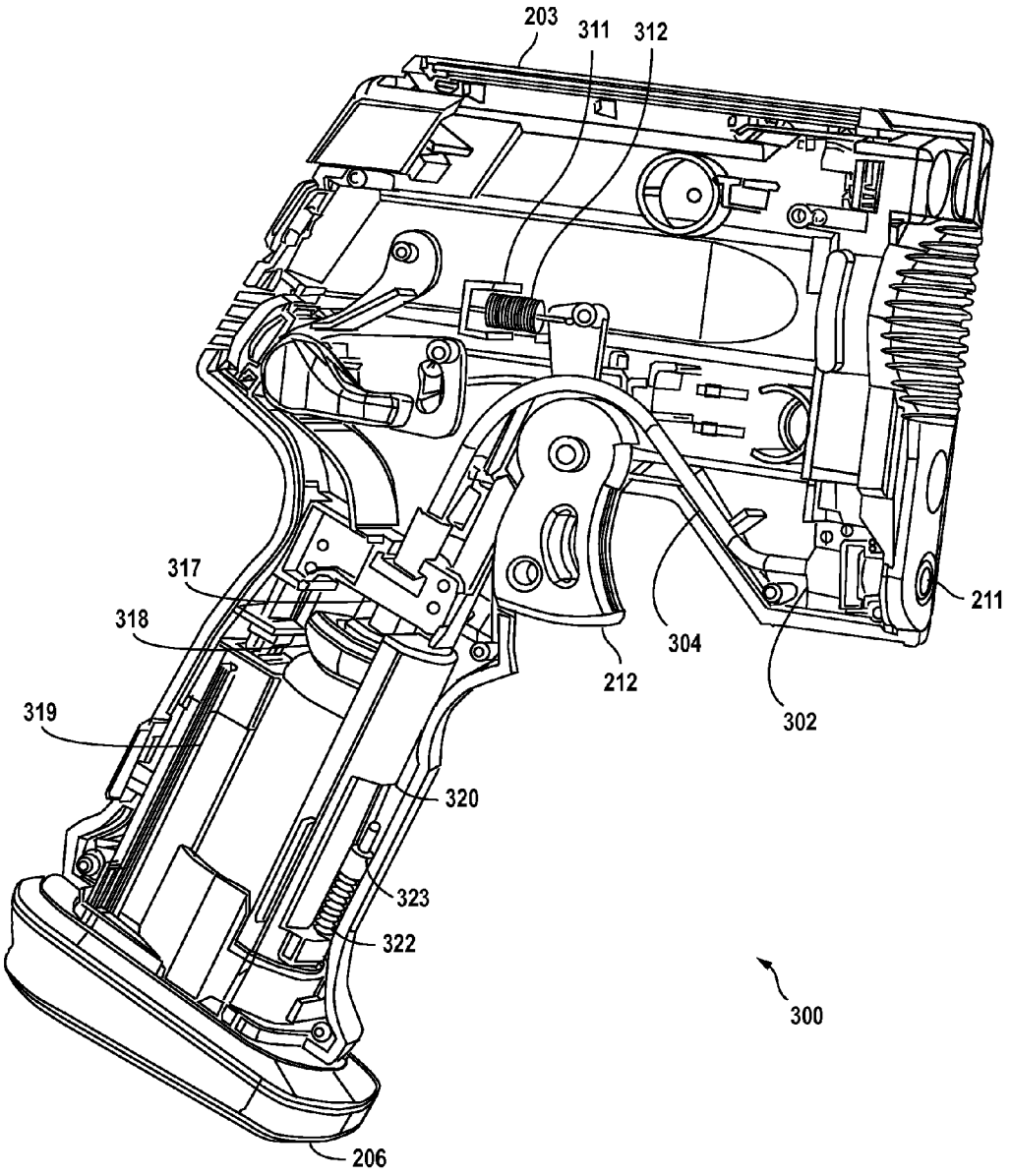


FIG. 3A

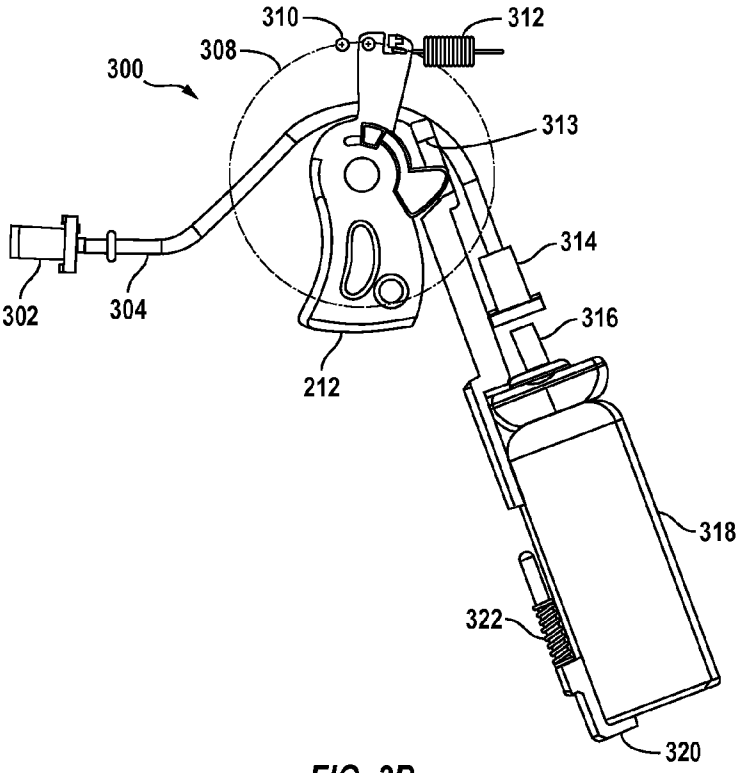

310
312
308
300
313
314
316
302
304
212
318
322
320

FIG. 3B

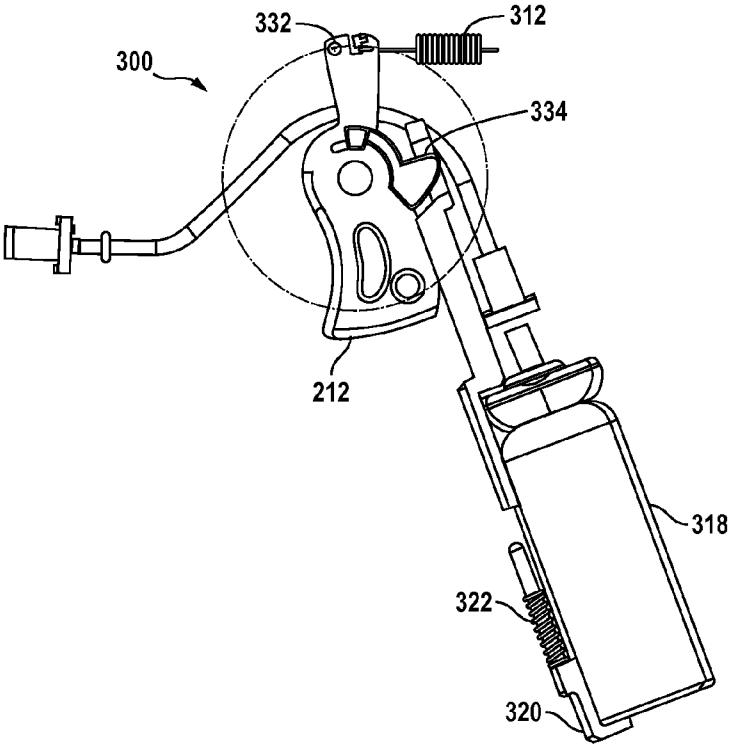

332
312
300
334
212
318
322
320

FIG. 3C

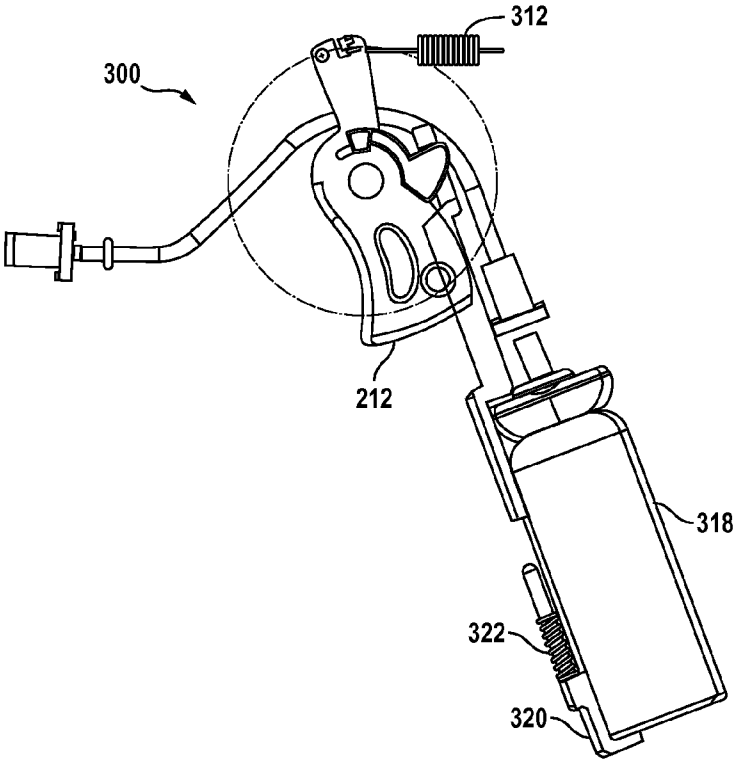


FIG. 3D

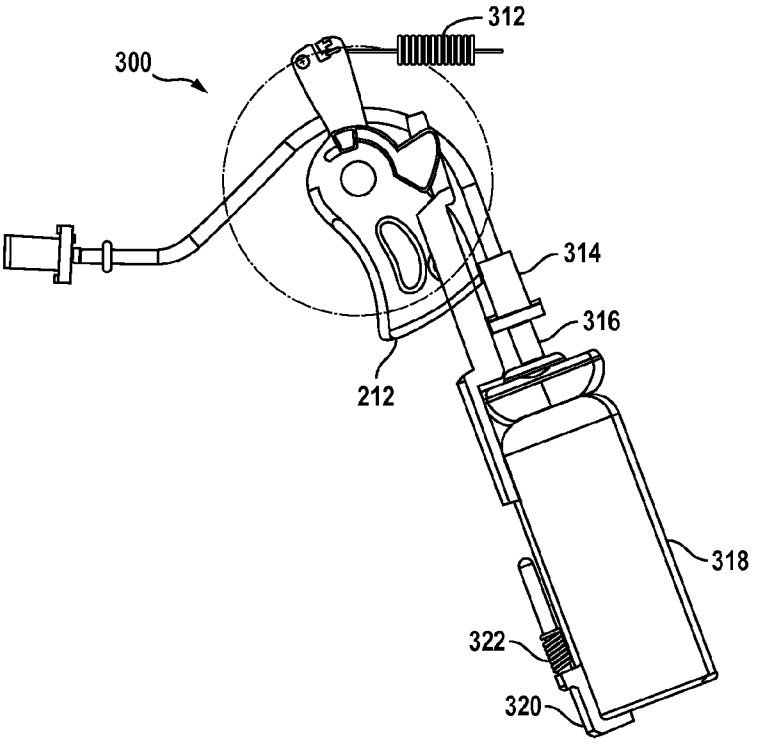


FIG. 3E

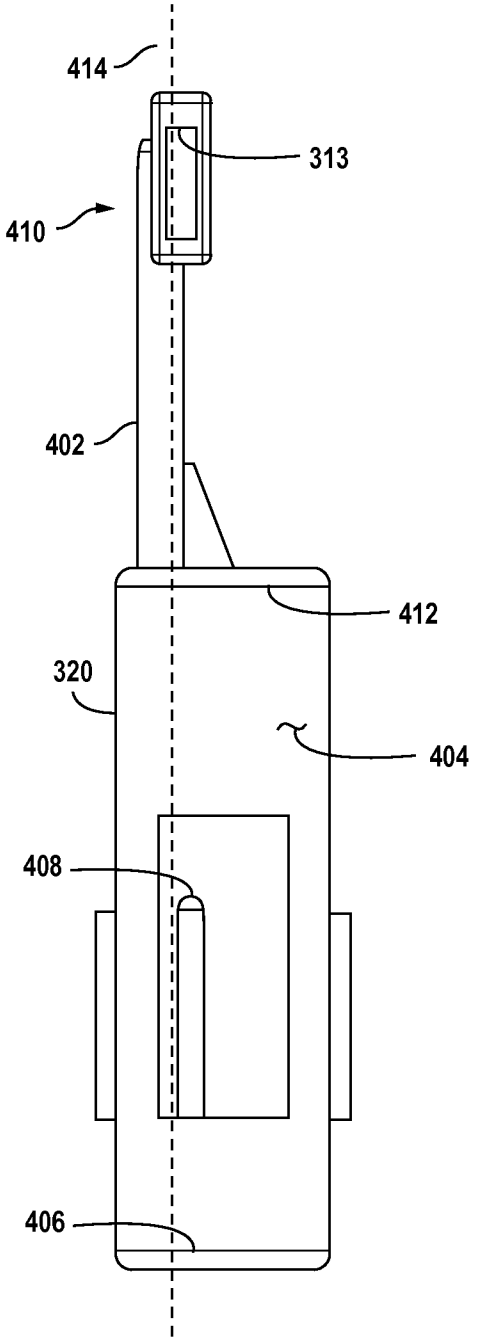


FIG. 4

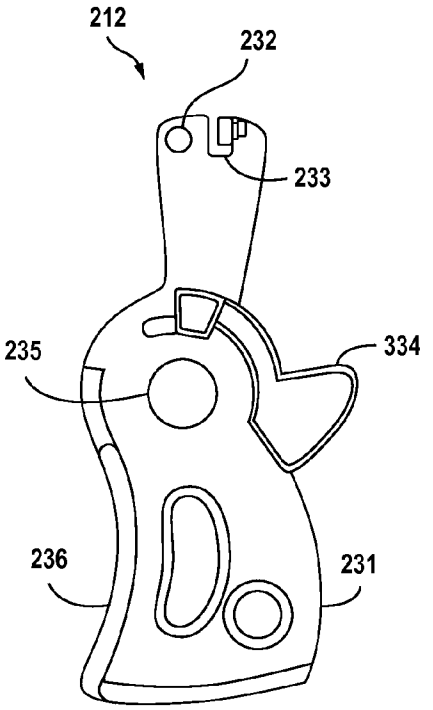

212
232
233
235
334
236
231

FIG. 5

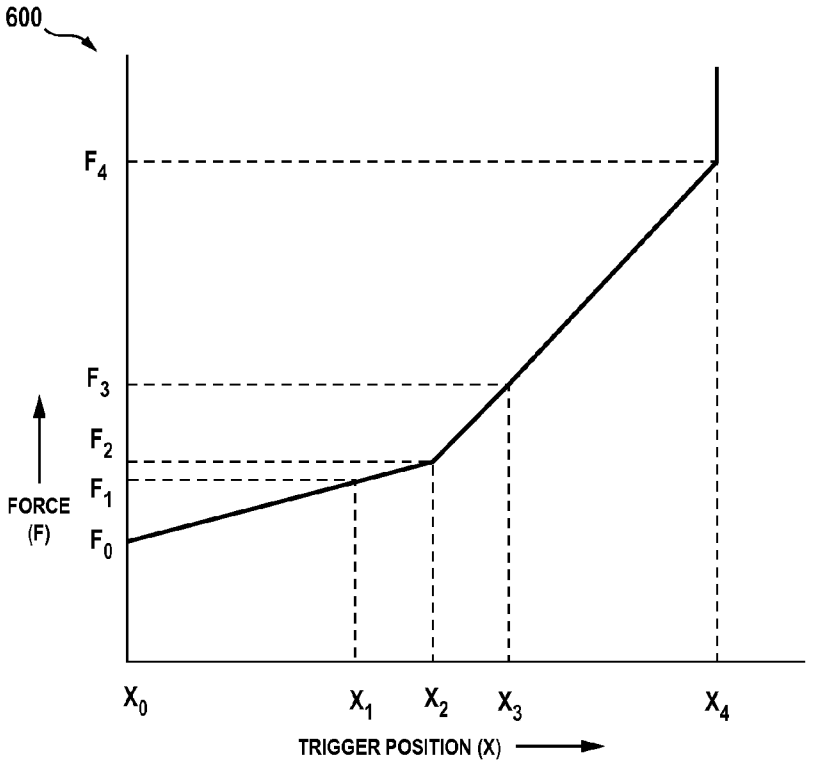

600
F4
F3
F2
F1
F0
FORCE
(F)
X0
X1
X2
X3
X4
TRIGGER POSITION (X)

FIG. 6

SYSTEMS AND METHODS FOR SPRAYING AN AEROSOL

BRIEF DESCRIPTION OF THE DRAWING

[0001] Embodiments of the present invention will be described with reference to the drawing, wherein like designations denote like elements, the terms left and right are from the perspective of a user looking in the direction of spray, and:

[0002] FIG. **1** is a functional block diagram of a system for spraying according to various aspects of the present invention;

[0003] FIG. **2**A is a perspective plan view of a system for spraying in one implementation according to various aspects of the present invention showing the left side and front;

[0004] FIG. **2**B is a perspective plan view of a system for spraying in one implementation according to various aspects of the present invention showing the right side and rear;

[0005] FIG. **3**A is a plan view of the interior of the left half of the housing of the system of FIGS. **2**A and **2**B;

[0006] FIGS. **3**B-**3**E are partial cross section views of a spray subsystem of the system for spraying of FIGS. **2**A and **2**B with the trigger switch at rest, the trigger switch at a first position, the trigger switch at a second position, and the trigger switch at a third position, respectively;

[0007] FIG. **4** is a front plan view of a shuttle of the spray subsystem of FIGS. **3**B-**3**E;

[0008] FIG. **5** is a left side view of a trigger switch of the spray subsystem of FIGS. **3**B-**3**E; and

[0009] FIG. **6** is a graph of force vs. position of a trigger switch of the system for spraying of FIG. **1** and the implementation of a system for spraying of FIGS. **2**A, **2**B, **3**A-**3**E, **4**, and **5**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] A system for spraying includes any apparatus that dispenses aerosol and comprises a user interface. A user may include a human operator. A user may include a robotic apparatus. A user interface includes any apparatus for initiating spraying.

[0011] A system for spraying, according to various aspects of the present invention, supports a canister that contains an aerosol and activates release of the aerosol from the canister in response to a range of positions of a trigger switch. In one implementation as a hand-held, hand-operated device or spray gun, a human user operates the trigger switch to cause activation and directs the aerosol.

[0012] According to various aspects of the present invention, a user of a system for spraying comprising a trigger switch experiences a change in the force vs. position of the trigger switch preceding activation of release of the aerosol. A possibility of unintended activation is reduced. Training on use of the system is simplified. In an implementation where the system includes circuitry for functions in addition to releasing aerosol, operation of the trigger switch up to the position where a change in force is experienced may facilitate, initiate, or perform one or more of those functions. Operation of the trigger switch may facilitate, initiate, or perform a series of functions wherein the series is determined at least in part by a series of positions of the trigger switch.

[0013] According to various aspects of the present invention, a system for spraying provides a user interface that includes a power switch, an arm switch, and a trigger switch. The system comprises circuitry for one or more of the following functions: with audio and/or light, warn of subsequent release of aerosol; cast light for illumination and/or direction identification before and/or during release of aerosol; log date, time, and/or location of release of aerosol; record sound; record still photographs; record video; provide notice via cellular telephone; and/or facilitate communication via cellular telephone. Operation of the power switch accomplishes initialization of the circuitry. Initialization may include facilitating operation of the system as a node of a wireless network. The arm switch in a first position mechanically interferes with operation of the trigger switch and in a second position permits unrestricted operation of the trigger switch. Before operation of the power switch or in the absence of sufficient power (e.g., no available power source, dead battery), activation of release of aerosol can be accomplished in response to operation of the trigger switch as permitted by the arm switch.

[0014] According to various aspects of the present invention, a system for spraying provides a user interface that includes a microphone, a speaker, a record switch, and a playback switch. The record switch initiates recording of sound via the microphone. The playback switch initiates playback of recorded sound via the speaker. In various implementations, the recorded sound may be used for one or more of the following: recording of the user's voice identifies the user of the system; recording of a system administrator's voice advises the user for the purpose of system status messages (e.g., warranty expiration date, periodic maintenance due date, initial battery capacity, initial aerosol capacity, description of installed aerosol, date of dispensing the system to the user, warnings, operating instructions directed to the user). Recorded sound, recorded via the microphone and/or prerecorded by the system administrator or system manufacturer, may be used during operation of the system (e.g., as a warning preceding activation of release of aerosol, as notice via a wireless network, as notice via cellular telephone communication). Pre-recordings may comprise data for synthesizing sounds.

[0015] According to various aspects of the present invention, a system for spraying provides a user interface that includes a power switch, a second switch, and circuitry including a processor and a transceiver for communication. The system, when operational, performs a method for linking in advance of communicating notice as discussed above. By linking in advance, notice is more timely transmitted. In one implementation, the method begins when the power switch enables power to the processor. The method performed by the processor from indicia of instructions read by the processor from a memory includes in any practical order: (a) detecting operation of the second switch; (b) establishing a communication link via the transceiver; (c) reducing power consumption of the system; and (d) transmitting via the link in response to the second switch. For example, the second switch may be operated or held in position by the user when the power switch is being operated or within a predefined period thereafter. In one implementation, the link supports Bluetooth™ protocol (a trademark of Telefonaktiebolaget LM Ericsson). Establishing the link comprises discovering and/or responding so as to be paired with another Bluetooth capable device (e.g., a cell phone, tablet, laptop, hotspot). Reducing power consumption may include entering a sleep mode of the processor, memory, or related circuitry, reducing

the range and/or recurring rate of transmitting, reducing the sensitivity of receiving, and/or removing power from portions of the circuitry of the system.

[0016] For example, system **100** of FIG. **1** is a system for spraying as discussed above. A functional block diagram of system **100** includes battery **102**, power switch **104**, power supply **106**, arm switch **110**, trigger switch **112**, position sensor **114**, push-to-talk switch **116**, record switch **118**, playback switch **120**, microphone **122**, video camera **124**, shuttle **130**, canister **132**, transceiver **134**, antenna **135**, processor **136**, memory **138**, displays **142**, audio deterrent **144**, visual deterrent **146**, and visual warning **148**. Mechanical apparatus and circuitry of system **100** may be constructed of conventional materials using conventional technologies including conventional computer programming technologies in light of the disclosure herein.

[0017] A user interface includes switches and may further include displays. A switch includes any mechanical and/or electrical apparatus of a user interface that has than one position or state. Movement from one state to another is generally responsive to action by the user. For example, system **100** may include conventional switches (e.g., slide, toggle, push-on/push-off, normally open momentary, normally closed momentary, magnetic proximity, optical, capacitive).

[0018] A display provides an indication to the user. The indication may describe a configuration, a capability, a condition, a status, an operating mode, a result of an operation, and/or a warning. For example, displays of system **100** may include conventional indicators (e.g., lamps, light emitting diodes, liquid crystal displays, field emission displays, displays comprising selectively excited phosphor surfaces).

[0019] System **100** comprises a user interface that includes power switch **104**, arm switch **110**, trigger switch **112**, position sensor **114**, push-to-talk switch **116**, record switch **118**, playback switch **120**, and displays **142**. Trigger switch **112** performs mechanical functions with respect to shuttle **130**. Trigger switch **112** and position sensor **114** cooperate to perform electrical functions. Arm switch **110** performs mechanical functions with respect to trigger switch **112** and performs electrical functions as discussed below.

[0020] A power switch includes any electrical switch that has an 'off' position and an 'on' position. For example, power switch **104** selectively electrically couples battery **102** to power supply **106**. Power is supplied to power supply **106** only when power switch **104** is set to the 'on' position. In one implementation, power switch **104** is a two-position slide switch that is not biased into either position, and includes mechanical hysteresis to maintain its current position.

[0021] An arm switch includes any apparatus for mechanical and electrical functions discussed herein. For example, arm switch **110** has two positions: a 'safety' position; and a position away from the 'safety' position. The second position may correspond to the safety-off position of conventional hand guns. In one implementation, arm switch **110** is a two-position rotary switch that is not biased into either position, and includes mechanical hysteresis to maintain its current position. An arm switch includes any apparatus that further mechanically interferes with operation of a trigger switch.

[0022] A trigger switch includes any apparatus having a first position electrically sensed and providing movement for proportional control. For example, trigger switch **112** has a 'rest' position, a first range of positions that includes a 'first deterrent' position, and a 'second deterrent' range of positions that facilitate proportional release of aerosol spray. Trigger switch **112** is biased to the 'rest' position. Arm switch **110** in its 'safety' position mechanically holds trigger switch **112** in the 'rest' position to reduce the possibility of unintended operation of trigger switch **112**. Trigger switch **112** cooperates with position sensor **114** so that a signal of position sensor **114** in accordance with obtaining the 'first deterrent' position effects circuitry of system **100**.

[0023] A push-to-talk switch, a record switch, and a playback switch include electrical switches implemented with or without latches that maintain an output signal or mode. For example, a user's manual momentary press and release of the respective switch may initiate a talk function, a record function, or a playback function until the user's manual second press and release of the respective switch. Latching may be accomplished with circuitry and/or software using conventional technologies. Push-to-talk switch **116**, record switch **118**, and playback switch **120** may be implemented as monetary electrical switches that are biased into a 'rest' position and require action by the user to set each into a respective 'active' position. Without a latch function, the user obtains the indicated function only while holding the momentary electrical switch in its 'active' position.

[0024] System **100** can operate without current from battery **102** as follows. Arm switch **110** in 'safety' position mechanically blocks effective movement of trigger switch **112**. A user may at any time move arm switch **110** out of the 'safety' position. After arm switch **110** is no longer in the 'safety' position, a user may at any time operate trigger switch **112** away from the 'rest' position to one or more other positions. When not in the 'rest' position, trigger switch **112** may mechanically urge shuttle **130** against force (e.g., one or more springs biased against trigger switch **112**, one or more springs biased against shuttle **130**, one or more springs biased against canister **132**, one or more springs biased against valves normally closed to retain aerosol within canister **132**). As shuttle **130** moves in response to movement of trigger switch **112**, valves in a spray subsystem (an example of which is discussed below) open to release aerosol from canister **132** as a spray output of system **100**. If the user does not overcome spring biasing, that biasing returns valves in spray subsystem closed to stop the release of aerosol.

[0025] System **100** is designed for battery-powered operation so that it can be carried and used apart from other sources of electricity. If desired, battery power may be replaced with a wired source of electricity, for example, with a sufficiently long and flexible cord to permit release of aerosol from suitable locations and in suitable directions.

[0026] Battery **102** provides power to system **100** when power switch **104** is set to the 'on' position and does not supply power when power switch **104** is set to the 'off' position. Battery **102** may be rechargeable in situ with conventional circuitry, not shown. Any conventional battery may be used.

[0027] A power supply includes any circuitry for converting power in one format to power in another format, each format, for example, has a characteristic (e.g., voltage amplitude; pulse period, repetition rate and duty cycle) suitable for empowering one or more functions of system **100**. For example, power from battery **102** is converted by power supply **106** to +5 volts DC and +/−12 volts DC measured with respect to system ground (e.g., circuit common). These voltages supply power as needed to other functional blocks of system **100**.

[0028] A processor includes any digital circuitry that performs a program stored in memory. A memory includes any conventional electronic and/or mechanical apparatus for storing digital information (e.g., RAM, ROM, Flash EPROM, disk). Memory circuits may be packaged with processor circuits as a controller, a microcontroller, a microprocessor, or a microcomputer. A processor may include input/output (I/O) circuitry for conversion of signaling technologies (e.g., analog, binary digital signals of nonstandard formats, impedance matching, latched inputs, latched outputs).

[0029] A transceiver includes any circuitry for sending and receiving wireless communication. Communication includes any conventional circuitry for suitable carriers, modulations, demodulation, packetization, and protocols.

[0030] According to various aspects of the present invention, system **100** performs a method for linking in advance of communicating notice as discussed above. By linking in advance, notice is more timely transmitted. In one implementation, the method begins when power switch **104** enables power supply **106** to energize processor **136**, memory **138**, and transceiver **134**. The method performed by processor **136** in response to reading indicia of instructions from memory **138** includes in any practical order: (a) detecting operation of push-to-talk switch **116**; (b) establishing a communication link via transceiver **134**; (c) reducing power consumption of the system; and (d) transmitting via the link in response to push-to-talk switch **116**. For example, push-to-talk switch **116** may be operated or held in position by the user when power switch **104** is set to the 'on' position or within a predefined period thereafter. In one implementation, the link supports Bluetooth™ protocol (a trademark of Telefonaktiebolaget LM Ericsson). Establishing the link comprises discovering and/or responding so as to be paired with another Bluetooth capable device (e.g., a cell phone, tablet, laptop, hotspot). Reducing power consumption may include entering conventional sleep modes of processor **136**, memory **138**, and/or related circuitry, reducing the range and/or recurring rate of transmitting, reducing the sensitivity of receiving, and/or removing power from portions of the circuitry of system **100**.

[0031] System **100** determines a notice that may at various times be customized and/or personalized to each user. To that end, processor **136** performs a method in accordance with indicia of instructions stored in memory **138**. After power is being supplied by power supply **106**, the user may set record switch **118** to the 'record' position. Speech or other audio is accepted by microphone **122** and indicia of audio is recorded in memory **138** as data for a notice. Microphone **122**, processor **136**, and/or memory **138** may include analog to digital conversion capability. Recording stops when memory capacity is filled and/or when record switch **118** is no longer in the 'record' position. The user may review the recorded notice by setting playback switch **120** to the 'playback' position. Indicia of audio, recalled from memory **138** may be formatted and directed to drive audio deterrent **144**, a conventional speaker, and/or be transmitted by transceiver **134** for review on a suitable receiver (e.g., cellular telephone, tablet, laptop computer). One purpose of the notice may be to inform an emergency assistance service as discussed below.

[0032] In addition to transmitting audio notice over a link as discussed above, system **100** transmits audio over a link in response to arm switch **110**, trigger switch **112**, and/or push-to-talk switch **116**. In one implementation processor **136** performs a method in accordance with instructions stored in memory **138**, after power is being supplied by power supply **106**. Processor **136** monitors the position of arm switch **110**. When arm switch **110** is no longer in the 'safety' position, processor **136** records sound from microphone **122** as data stored in an audio circular buffer in memory **138** that keeps about 30 seconds of recorded sound. If trigger switch **112** is moved against spring bias out of a 'rest' position to a 'first deterrent' position, processor **136**, in any practical order, activates audio deterrent **144**, activates visual deterrent **146**, activates visual warning **148**, activates video camera **124** and records video into a video circular buffer in memory **138** that keeps about 15 minutes of video, issues instructions over the link established as discussed above to a cellular phone to place a call to an emergency assistance service (e.g., a 9-1-1 service), and performs playback of the recorded notice created as discussed above to inform the emergency assistance service. If a cellular phone call has been established, then processor **136** may facilitate transmitting over the cellular phone call audio from any one (e.g., alternatingly) of the following sources: recorded sound from the audio circular buffer in memory **138**, the recorded notice, live ambient sound responsive to microphone **122**, and live speech or sound responsive to microphone **122** further in response to push-to-talk switch **116** being held at the 'talk' position. Processor **136** may silence audio deterrent **144** in response to push-to-talk switch **116** being held at the 'talk' position.

[0033] Inputs to processor **136** may be coupled to processor **136** in any conventional manner, represented generally by bus **126**. Various additional circuitry (not shown) may be used (e.g., discrete circuitry for each input, de-bounce circuits, sampling circuits, multiplexers, addressed I/O logic, analog to digital conversion circuitry, comparators, amplifiers, digitizers).

[0034] Conventional digital communication is supported by bus **128** and any conventional protocols. Video camera **124**, transceiver **134**, processor **136**, and memory **138** may read and/or write data from and to any suitable combination of these devices. Data may include status, commands, responses, acknowledgements, packets, and information to facilitate any function of system **100** as discussed herein.

[0035] Outputs from processor **136** may be coupled to processor **136** in any conventional manner, represented generally by bus **140**. Various additional circuitry (not shown) may be used (e.g., discrete circuitry for each output, latching circuits, multiplexers, addressed I/O logic, digital to analog conversion circuitry, amplifiers).

[0036] An audio deterrent produces sound to frighten, distract, or debilitate a human or animal and is activated by the user for purposes of self-defense. Any conventional sound deterrent technology may be used including high volume, volume bursts, high pitch, low pitch, imitations of frightening sounds such as sirens, whistles, screams, or the ranting of attacking animals. For example, audio deterrent **144** produces an 80 dB siren howl.

[0037] A visual deterrent produces light to frighten, distract, or debilitate a human or animal, and is activated by the user for purposes of self-defense. Any conventional light deterrent technology may be used including temporarily blinding light, rapidly flashing light, imitations of frightening lights such as colors used exclusively by police and laser colors associated with weapon sights. For example, visual deterrent **146** emits high intensity white strobe light to cause temporary blindness and/or disorientation.

[0038] A visual warning may be emitted in any direction to inform other persons within a reasonable range of system **100** that deterrents including sound, light, and aerosol spray may be activated without further notice. For example, visual warning **148** may emit a suitable color (e.g., yellow, orange, red) of incoherent light to the left and to the right of system **100**.

[0039] According to various aspects of the present invention, system **100** responds differently to more than one position of trigger switch **112** in addition to the 'rest' position. As discussed above, trigger switch **112** may have a 'first deterrent' position and a 'second deterrent' range of positions. Functions of system **100** initiated by trigger switch **112** entering the 'first deterrent' position (regardless of how long trigger switch **112** remains in the 'first deterrent' position) may be as discussed above. Aerosol spray may be initiated and continued while trigger switch **112** remains in the 'second deterrent' range of positions.

[0040] A position sensor detects and reports indicia of position of an object in any conventional manner of detecting and reporting. Position may be determined directly, or determined from velocity or acceleration of the object and reported directly as position or as velocity or acceleration according to conventional position sensor technologies. A position sensor may include conventional magnetic (e.g., proximity of a magnet or magnetically permeable material) and/or optical technologies (e.g., intensity of a light source or reflection, beam break).

[0041] For example, position sensor **114** detects magnetic flux associated with a portion of trigger switch **112**. When magnetic flux intensity or a rate of change thereof crosses a predetermined limit value, then position sensor **114** informs (e.g., writes) or makes data available (e.g., awaits being read) to inform processor **136** to the effect that trigger switch **112** has entered the 'first deterrent' position.

[0042] A shuttle includes any mechanism that locates a canister for proper initiation of aerosol output from the canister in response to (e.g., directly, indirectly, in accordance with position of) a trigger switch. A shuttle may retain a canister. A shuttle may locate and/or retain more than one canister. A canister may comprise a valve operated in response to movement of the shuttle. A canister may comprise a vent opened in response to movement of the shuttle. A shuttle may seal a canister and operate to open the seal in response to movement of the shuttle. A vent, valve, or seal may be re-closeable or non-recloseable.

[0043] For example, shuttle **130** retains canister **132** and moves canister **132** so as to open a valve that may be integral to canister **132**. Movement is against spring bias in the valve so that when shuttle **130** returns to a 'rest' position, the valve recloses. Movement in a range of positions of shuttle **130** may facilitate proportionally opening the valve for proportionally more or less volume and/or velocity of output spray.

[0044] The functions discussed herein for a canister may be integrated into an aerosol-containing shuttle for an implementation that omits a separable canister.

[0045] System **100** in one implementation is a weapon designed to be hand-held, battery operated, and used for self-defense. Weapon **200** is not a firearm and is unlikely to be a sole cause of death or serious injury of humans. For example, as shown in FIGS. **2-6**, weapon **200** includes features corresponding generally to the functional blocks discussed above. Functional blocks are indicated parenthetically for reference. Weapon **200** includes enclosure **202**, handle **204** (e.g. an integral portion of enclosure **202**), base **206**, and front face **208** (e.g. an integral portion of enclosure **202**). Weapon **200** encloses spray subsystem **300** (see FIG. **3**A). On front face **208** are located lens **207** for a visual deterrent (**146**) and a video camera (**124**), a radiator **209** for an audio deterrent (**144**), visual warning (**148**) **205**, laser sight (**148**) **210**, and spray outlet **211**. A user interface of weapon **200** includes trigger switch (**112**) **212**, arm switch (**110**) **213**, power switch (**104**) **218**, record switch (**118**) **222**, playback switch (**120**) **220**, push-to-talk (**116**) switches **214** and **216**, and displays (**142**) **224**. For ambidextrous operation, arm switch **213** and push-to-talk switches **214** and **216** have mechanical and/or electrical equivalents positioned equivalently on both sides of weapon **200**. A circuit board (omitted for clarity of description of spray subsystem **300**) includes circuitry for all functions discussed with reference to FIG. **1**, namely, a power supply (**106**), microcontroller (**136**, **138**), transceiver (**134**), antenna (**135**), circuitry for audio and visual deterrents (**144**, **146**), microphone (**122**), and video camera (**124**).

[0046] A user may perform a method of operating the system including: removing base **206**; installing a canister **318** of aerosol spray (e.g., pepper spray); installing a battery (**102**) **319**; and replacing base **206**. If battery **319** is absent or not sufficiently charged, aerosol spray may be dispensed mechanically by moving arm switch **213** away from a 'safety' position; directing spray outlet **211** of front face **208** toward a human or animal to be sprayed; and controlling the dispensing of aerosol spray by pulling and releasing trigger switch **212**.

[0047] If the battery has sufficient charge to operate circuitry of system **100** including a processor and display, system **100** may respond to the user's act of sliding power switch **218** to the 'on' position by illuminating display **224** as notice that no communication link has been established. The processor performs a method similar in some ways to the method discussed above including detecting whether push-to-talk switch **214** or **216** is operated by the user within a limit period of time relative to operation of power switch **218**. If not, then the processor operates display **224** to provide notice to the user (e.g. red light is emitted).

[0048] If the battery has sufficient charge to operate circuitry of system **100** including a processor and a transceiver, the system may respond to the user's act of sliding power switch **218** to the 'on' position and operating push-to-talk switch **214** or **216** within a limit period of time by: (a) establishing a communication link via a transceiver of the system circuitry; and (b) reducing power consumption of the system. The processor may control the transceiver with a signal or command to reduce power consumed by the transceiver; and the processor may change to a low power mode (e.g., sleep mode) where transition out of the sleep mode may be responsive to setting arm switch **106** to an arm position. During low power mode, the communication link (e.g., pairing) is maintained ready for immediate use (e.g., without repeating steps of initializing, discovering, identifying, configuring, verifying configuration).

[0049] A spray subsystem, according to various aspects of the present invention, facilitates activation of a series of deterrents. For example, a series comprising one or more first deterrents followed in time by second deterrents as discussed herein.

[0050] A spray subsystem, according to various aspects of the present invention facilitates a series of functions of a system for spraying. For example, a system for spraying performs a series of functions including initializing a com-

munication capability, operating a communication capability, operating an incident recording capability, and releasing aerosol spray. A spray subsystem, according to various aspects of the present invention comprises a shuttle and a trigger switch wherein the shuttle and the trigger switch cooperate with discontinuous mechanical coupling. According to various aspects of the present invention, the trigger switch may provide a discontinuity in bias against operation of the trigger switch by the user. These aspects are realized in a spray subsystem **300** of FIGS. **3**A-**3**E, **4**, and **5**.

[0051] Spray subsystem **300** is located within enclosure **202** of weapon **200** shown in FIGS. **2**A and **2**B. Spray subsystem **300** includes exit valve **302**, tube **304**, entry valve **314**, trigger switch **212**, shuttle **320**, and canister **318** having canister outlet valve **316**. In the side view of FIG. **3**A, spray subsystem **300** is located against the inside surface of left side **203** of enclosure **202**. Stop **317** maintains alignment of entry valve **314** and canister outlet valve **316**.

[0052] In the partial cross section views of FIGS. **3**B-**3**E, shuttle **320** is shown in a section identified by plane **414** in FIG. **4**. Canister **318** is shown supported by shuttle **320** and in a section with reference to the same plane **414**.

[0053] A valve, as discussed herein, includes any conventional check valve for a fluid (e.g., gas, liquid, suspension, aerosol). For example, canister outlet valve **316**, entry valve **314**, and exit valve **302** may comprise duck-bill check valves that open in response to a prescribed minimum pressure and otherwise close in response to bias of the valve design. Bias may be provided by a spring or any other conventional materials or components.

[0054] A tube includes any structure having a passage that transports a fluid. Tube **302** may be rigid, formed of stainless steel.

[0055] With reference to FIGS. **3**B-E, when the user applies pressure to trigger switch **212**, trigger switch **212** pivots into abutting contact with shuttle **320**. After contact occurs, continued pressure by the user on trigger switch **212** causes trigger switch **212** to urge shuttle **320** upward. As shuttle **320** moves upward, shuttle **320** lifts canister **318**. As canister **318** is lifted, canister **318** compresses canister outlet valve **316** against entry valve **314** and thereby opens canister outlet valve **316**. Pressure of the aerosol opens entry valve **314** and exit valve **302**. When canister outlet valve **316** is open, aerosol spray travels through canister outlet valve **316**, entry valve **314**, tube **304**, exit valve **302**, and spray outlet **211** of front face **208**.

[0056] Operation of spray subsystem **300** will now be further described with reference to FIGS. **3**B-**3**E and FIG. **6**. In FIG. **3**B, trigger switch **212** is at the 'rest' position indicated as X**0** in graph **600**. In FIG. **3**C, trigger switch **212** is at a 'first deterrent' position indicated as X**1** in graph **600**. In FIG. **3**D, trigger switch **212** is at a beginning of a range of positions indicated as X**2**-X**3** in graph **600**. In FIG. **3**E, trigger switch **212** is at an end position X**4** of a 'second deterrent' range of positions indicated as X**3**-X**4** in graph **600**.

[0057] Spray system **300** further includes trigger bias spring **312**. Trigger bias spring **312** provides a trigger bias spring bias force that maintains trigger switch **212** in 'rest' position X**0** by opposing force (if any) exerted by the user of weapon **200** to move trigger switch **212** away from 'rest' position X**0**. As trigger switch **212** pivots at the center of reference circle **308**, trigger bias spring **312** extends, increasing this trigger bias spring bias force.

[0058] Spray system **300** further includes shuttle bias spring **322**. Shuttle bias spring **322** provides a bias force that maintains shuttle **320** at a 'rest' position to assure opening of canister outlet valve **316** is intended by the user of weapon **200**. When shuttle bias spring **322** is compressed against stop **323**, shuttle **322** is urged by shuttle bias spring **322** to return to its 'rest' position as shown in FIGS. **3**A-**3**D.

[0059] Canister outlet valve **316** has a return spring (not shown). This return spring cooperates with shuttle bias spring **322** to provide a combined bias against force exerted by the user of weapon **200** against trigger switch **212**. According to various aspects of the present invention, the combined bias increases at a rate different (e.g., greater) than the trigger bias spring bias force discussed above. Consequently, a first increasing force exerted by the user to move trigger switch **212** in a first range of positions X**0**-X**2** is noticeably at a different rate of increase than a second increasing force exerted by the user to move trigger switch **212** in a second range of positions X**2**-X**4**. In other words, in an exemplary implementation, the respective spring constants of trigger bias spring **312**, return spring of canister outlet valve **316**, and shuttle bias spring **322** are designed to generally provide the force vs. position relationship of graph **600** where forces F**0**-F**4** represent a series of ever increasing forces matched by the user of system **100** to attain and/or leave trigger switch positions X**0**-X**4**.

[0060] The graph of FIG. **6** presents a simplified linearized approximation of the reaction force F that a user of weapon **200** would experience when applying pressure against trigger switch **212** at various angular positions X**0**-X**4** measured about the center of circle **308**. A model of the actual force as a function of position X would account for nonlinear stretching of trigger bias spring **312** and nonlinear compression of shuttle bias spring **322** for values of X from X**0**-X**4**.

[0061] A position sensor may include a fixed portion and a moving portion. A fixed portion of position sensor **310** is mounted on a circuit board (not shown) and located on reference circle **308**. A moving portion comprises magnet **332** of trigger switch **212**. As trigger switch **212** moves into 'first deterrent' position X**1**, magnet **332** operates the fixed portion to indicate to circuitry that the 'first deterrent' position has been accomplished. The fixed portion of position sensor **310** comprises a conventional magnetic proximity switch. Circuitry including proximity switch **310** is coupled to a processor to notify the processor when trigger switch **212** is in the 'first deterrent' position.

[0062] Trigger switch **212** is coupled to shuttle **320** when surface **334** of trigger switch **212** abuts surface **313** of shuttle **320**. Opening **410** of shuttle **320** comprising surface **313** accepts a portion of trigger switch **212** comprising surface **334**. These surfaces are not mechanically coupled for cooperation when trigger switch **212** is in a first range of positions X**0**-X**2**. These surfaces are mechanically coupled for cooperation when trigger switch **212** is in a second range of positions X**2**-X**4**. Because there is no tactile feedback to the user at position X**1** of trigger switch **212**, the user learns that trigger switch **212** has achieved the 'first deterrent' position X**1** and is now beyond position X**1** when tactile feedback is available at position X**2**. The range of positions X**1**-X**2** accommodates manufacturing tolerances. The range of positions X**1**-X**2** when greater than about 10% of the range X**0**-X**2** makes system **100** easier to use, for instance because proper operation is less dependent on the user moving trigger switch **212** to a narrowly defined position such as X**1** itself. The

range of positions X1-X2 can be made greater than about 10% of the range X0-X2 by conventional design techniques for the size and shape of trigger switch **212** relative to the position and size of opening **410** of shuttle **320**.

[0063] A shuttle may include a base for lifting a canister, and an operative surface for coupling to a trigger switch. The base and operative surface may be in fixed relationship. For example, the base and operative surface may be features of a rigid structure that forms the shuttle. In one implementation, shuttle **320** is rigid, formed of conventional plastic.

[0064] The operative surface of the shuttle comprises any portion of the shuttle that cooperates (e.g., abuts, impinges) with a portion of a trigger switch. The operative surface may be an inside surface of a feature (e.g., aperture, hook, L-shape, box, cup, loop). The trigger switch may, after coming into contact with the operative surface of the shuttle, form a coupling (e.g., hinge, joint, ball and socket). Mechanical coupling of the operative surface and the trigger switch may include abutting, sliding, and/or impinging. The operative surface may be located on the shuttle at a distance away from the canister. The operative surface may be located beside the canister. The operative surface may be located on the shuttle at a distance above or below the canister.

[0065] The base of a shuttle includes an surface capable of urging open the canister outlet valve. The base may abut a lower extremity of a canister (e.g., lift the canister by a surface of the canister abutting the shuttle when the shuttle is in a 'rest' position). A base may abut, grasp, and/or impinge a portion of a canister above the lower extremity (e.g., urge the canister to open the canister outlet valve by contact with a feature near the top, at a neck, and/or of a wall of the canister).

[0066] A spring, as used herein, includes any device that provides a mechanical force in response to a position or change of position. Spring includes any conventional spring (e.g., coil, leaf, torsion spring, flat wound, strip, cord) operative by extension, compression, bending, or twisting. A spring includes devices of conventional materials (e.g., solids, liquids, gels, gases) having resilient and/or elastic characteristics.

[0067] A shuttle bias spring includes any device coupled to a shuttle and/or any integral portion of a shuttle that provides a force to close a canister exit valve and/or return the shuttle to a 'rest' position.

[0068] For example, shuttle **320** includes base **406**, post **408**, top **412**, and arm **402**. Base **406** and top **412** define the vertical extent of interior space **404** sized for retaining a conventional canister containing under pressure an aerosol (e.g., oleoresin capsicum, pepper spray). Arm **402** comprises opening **410**. A top portion of opening **410** is defined by surface **313** of arm **402**. In operation, canister **318** abuts base **406** at all times. When shuttle **320** is lifted by trigger switch **212**, shuttle **320** lifts canister **318** by force applied from base **406** to a lower extremity of canister **318**. Pressure of surface **234** of trigger switch **212** is communicated through arm **402** to lift base **406** and canister **318**. Post **408** confines shuttle bias spring **322** during compression of shuttle bias spring **322** against stop **323** as shuttle **320** moves away from its 'rest' position. Top **412** may abut a top surface of canister **318** to assure that canister outlet valve **316** is pulled away from entry valve **314** as shuttle **320** returns to its 'rest' position.

[0069] A trigger switch for operation in a spray subsystem according to various aspects of the present invention includes structure for position sensing, structure for cooperation with a trigger bias spring, and structure for cooperation with a shuttle. For example, trigger switch **212** of FIG. **5** includes switch body **231** and magnet **232**. Switch body **231** includes features identified as mount **233**, surface **234**, aperture **235**, and finger grip **236**.

[0070] In one implementation, trigger switch **212** is an assembly. Switch body **231** is formed of rigid conventional plastic. Magnet **232** is pressed into position in a suitable aperture of switch body **231**. Trigger bias spring **312** may be coupled to switch body **231** in any conventional manner (e.g., threaded into mount **233**, threaded into a suitable aperture of body **231**, mounted coaxially to oppose rotation of trigger body **231** about aperture **235**).

[0071] Aperture **235** supports switch body **231** on a suitable post feature of body **203**. Aperture **235** facilitates rotation of switch body **231** about a center of aperture **235** coaxial to circle **308** discussed above.

[0072] Finger grip **236** provides a comfortable surface for the user to operate trigger switch **212** with an index finger in a conventional manner.

[0073] In the implementations discussed above with reference to FIGS. **2**A, **2**B, **3**A-**3**E, **4**, and **5** body **202** includes handle **204** at an angle from a horizontal top portion of weapon **200**. Trigger switch **212** provides rotational motion about circle **308** to open canister outlet valve **316**. Space for a canister is provided in a handle of the weapon. Other implementations are within the scope of the present invention.

[0074] For example, a weapon having analogous functions supports a canister substantially parallel to the direction of spray. A trigger switch in such an implementation may operate by movement along a substantially straight line instead of about an axis of rotation as discussed above. Movement of the trigger switch may be confined to a track having any suitable linear or nonlinear form. A handle may be provided at an angle to the direction of spray, substantially parallel to the direction of spray, or omitted (e.g., for use against a human user's shoulder or for use by a robotic user).

[0075] For example, a canister may include a canister release valve that is opened using rotational force (in contrast with linear force for canister **318** discussed above). A trigger switch and shuttle may be arranged in linear format (e.g., similar to rack (trigger) and pinion (shuttle) coupling), arranged in coaxial coupling (both trigger and shuttle rotate on the same axis), or arranged in counter rotational coupling (analogous to the way two disc-shaped gears mesh on their circumferences).

[0076] In all of these alternatives, movement of the trigger switch causes movement of the shuttle only after an initial range of motion of the trigger switch (e.g., after a position analogous to position X2 of FIG. **6**).

[0077] Examples of systems for spraying and methods performed by systems for spraying, according to various aspects of the present invention, include the following.

[0078] As a first example, a system for spraying includes a trigger switch, a first spring, a second spring, and a canister of aerosol. The first spring is coupled to the trigger switch to oppose operation of the trigger switch. The second spring is not coupled to the trigger switch during a first range of positions of the trigger switch and is coupled to the trigger switch during a second range of positions of the trigger switch. During the second range of positions of the trigger switch, the first spring and the second spring oppose operation of the trigger switch without release of the aerosol. During a third range of positions of the trigger switch, the first spring and the

second spring oppose operation of the trigger switch in a range of positions with release of the aerosol.

[0079] As a second example, a variation of the first example, the system further includes a shuttle operative when coupled to the trigger switch to open the canister to release the aerosol; and during the first range of positions of the trigger switch, the shuttle is not coupled to move in response to the trigger switch.

[0080] In a variation of the second example, the second spring is coupled to the shuttle to oppose movement of the shuttle.

[0081] In another variation of the second example, the system is useful for self-defense against an attacker. The system further includes circuitry and a position sensor. The circuitry provides a deterrent to aggression by the attacker. The position sensor enables the circuitry to provide the deterrent after the trigger switch is operated beyond a first portion of the first range and before the trigger switch is operated in the second range.

[0082] In another variation of the first example, the system is useful for self-defense against an attacker. The system further includes circuitry and a position sensor. The circuitry provides a deterrent to aggression by the attacker. The position sensor enables the circuitry to provide the deterrent after the trigger switch is operated beyond a first portion of the first range and before the trigger switch is operated in the second range.

[0083] As a third example, a system for spraying includes a canister, a tube, a trigger switch, a first spring, and a second spring. The canister comprises an outlet valve biased closed. The tube comprises an entry valve and an exit valve. The first spring is biased to return the trigger switch to a rest position. The second spring is biased to return the canister to a rest position. Movement of the trigger by a user of the system when opposed by only the first spring does not open the outlet valve. Movement of the trigger by a user of the system when opposed by only the first spring and the second spring does not open the outlet valve. Movement of the trigger by a user of the system when opposed by the first spring, the second spring, and the bias of the outlet valve opens the outlet valve to form a spray comprising contents of the canister.

[0084] As a fourth example, a system for spraying includes a canister of aerosol, a circuit, and a trigger switch. The trigger switch provides a force as a function of position, the force opposing operation of the trigger switch by a user. The force increases at a first average rate in a first range from a rest position of the trigger switch to a tactile feedback position of the trigger switch. The force increases at a second average rate greater than the first average rate in a second range from the tactile feedback position to a maximum position of the trigger switch. The circuit is enabled to output an audio deterrent at a position within the first range spaced respectively from each extreme of the first range. The canister is opened to release aerosol in a portion of the second range that is less than the entire second range.

[0085] As a fifth example, a spray subsystem comprises a shuttle and a trigger switch. The shuttle and the trigger switch cooperate with discontinuous mechanical coupling. The trigger switch provides a discontinuity in bias against operation of the trigger switch by the user.

[0086] As a sixth example, a spray subsystem includes a shuttle and a trigger switch. The trigger switch moves in a first range of positions before abutting the shuttle. The trigger switch moves in a second range of positions while abutting the shuttle to move the shuttle. Movement of the trigger switch is opposed by a first spring. Movement of the shuttle is opposed by a second spring.

[0087] In a variation of the sixth example, a portion of the trigger switch passes through an opening of the shuttle before the trigger switch abuts the shuttle.

[0088] As a seventh example, a trigger switch for operation in a spray subsystem, includes a portion of a position sensor (e.g., a sensor, a characteristic capable of being sensed), a mount, and a surface. The position sensor senses the position of the trigger switch as operated by a user of the spray subsystem. The mount accepts a spring to oppose movement of the trigger by the user of the trigger switch. The surface mechanically cooperates with a provided canister to release a spray from the canister.

[0089] In a variation of the seventh example, the portion of the position sensor includes a magnet.

[0090] As an eighth example, a system for spraying for self-defense against an attacker includes a power switch, an arm switch, a trigger switch, circuitry, and a canister. The circuitry provides a notice via a wireless link and for recording audio and video of the attacker. The canister contains aerosol. The circuitry, in response to operation of the power switch, enables operation of the system as a node of a wireless network. The circuitry, in response to operation of the arm switch, records audio and video of the attacker. The notice is provided via the wireless link in response to operation of the trigger switch. The aerosol is released toward the attacker in response to operation of the trigger switch.

[0091] As a ninth example, a method is performed by a processor that reads indicia of instructions for the method from a memory. The processor and memory are part of a system operated by a user. The system further comprises a power switch, a second switch, and a transceiver. The method is performed when the power switch couples power to the processor and the memory. The method includes in any practical order, the steps of (a) detecting a first operation by the user of a second switch; (b) in response to detecting, establishing a communication link via the transceiver and reducing power consumption of the system; and (c) transmitting via the link in response to a second operation by the user of the second switch.

[0092] In a variation of the ninth example, the first operation of the second switch is detected if the second switch is held in position by the user within a predefined period after power is coupled to the processor.

[0093] In another variation of the ninth example, establishing the link comprises responding so as to be paired with a node of a network.

[0094] In another variation of the ninth example, reducing power consumption comprises entering a sleep mode of at least one of the processor and the memory.

[0095] In another variation of the ninth example, reducing power consumption comprises reducing a recurring rate of transmitting by the transceiver.

[0096] In another variation of the ninth example, reducing power consumption comprises reducing the sensitivity of receiving by the transceiver.

[0097] As a tenth example, a method is performed by a system for spraying. The system is operated by a user. The method includes in any practical order, the steps of (a) initializing a communication capability of the system in response to operation by the user of a first switch of the system; (b) operating a communication capability in response to opera-

tion by the user of a second switch; (c) operating an incident recording capability in response to operation by the user of a third switch; and (d) releasing aerosol spray in response to operation by the user of a fourth switch.

[0098] The foregoing description discusses preferred embodiments of the present invention, which may be changed or modified without departing from the scope of the present invention as defined in the claims. As used herein, the term 'coupled' is used for explaining cooperation (e.g., electrical communication, mechanical communication) that may be direct or indirect (e.g., through intervening mechanical, through intervening electrical components). As used herein, the term 'generally' is used for explaining a component or process in an implementation where in other implementations of the present invention each of the narrower terms 'substantially', 'primarily', and 'exclusively' is specifically intended to be disclosed and to apply. These relationships correspond to relative effectiveness of the component or process such as generally about 50% effective, substantially about 80% effective, primarily about 95% effective, and exclusively meaning 100% effective. The term 'about' means a factor of +/−15%. The examples listed in parentheses may be alternative or combined in any manner. The invention includes any practical combination of the structures and methods disclosed. As used in the specification and claims, the words 'having' and 'including' in all grammatical variants are open-ended and synonymous with 'comprising' and its grammatical variants. While for the sake of clarity of description several specifics embodiments of the invention have been described, the scope of the invention is intended to be measured by the claims as set forth below.

What is claimed is:

1. A system for spraying comprising:
a. a trigger switch;
b. a first spring coupled to the trigger switch to oppose operation of the trigger switch;
c. a second spring not coupled to the trigger switch during a first range of positions of the trigger switch and coupled to the trigger switch during a second range of positions of the trigger switch; and
d. a canister containing an aerosol; wherein
e. during the second range of positions of the trigger switch, the first spring and the second spring oppose operation of the trigger switch without release of the aerosol; and
f. during a third range of positions of the trigger switch, the first spring and the second spring oppose operation of the trigger switch in a range of positions with release of the aerosol.

2. The system of claim **1** wherein:
a. the system further comprises a shuttle operative when coupled to the trigger switch to open the canister to release the aerosol; and
b. during the first range of positions of the trigger switch, the shuttle is not coupled to move in response to the trigger switch.

3. The system of claim **2** wherein the second spring is coupled to the shuttle to oppose movement of the shuttle.

4. The system of claim **1** wherein:
a. the system further comprises a shuttle operative to open the canister to release the aerosol;
b. during the first range of positions of the trigger switch, the trigger switch does not abut the shuttle to move the shuttle in response to the trigger switch; and
c. during the third range of positions of the trigger switch, the trigger switch abuts the shuttle to move the shuttle in response to the trigger switch.

5. The system of claim **4** wherein a portion of the trigger switch passes through an opening of the shuttle before the trigger switch abuts the shuttle.

6. The system of claim **1** wherein the trigger switch comprises:
a. means for position sensing of a position of the trigger switch as operated by a user of the system;
b. a mount that accepts the first spring to oppose operation of the trigger switch; and
c. a surface mechanically coupled to the canister to release a spray from the canister.

7. The trigger switch of claim **6** wherein the means for position sensing comprises a magnet.

8. The system of claim **1** for self-defense against an attacker, the system further comprising:
a. circuitry for providing a deterrent to aggression by the attacker; and
b. a position sensor that enables the circuitry to provide the deterrent after the trigger switch is operated beyond a first portion of the first range and before the trigger switch is operated in the second range.

9. A system for spraying comprising:
a. a canister containing an aerosol;
b. a circuit; and
c. a trigger switch; wherein:
d. the trigger switch provides a force as a function of position, the force opposing operation of the trigger switch by a user;
e. force increases at a first average rate in a first range from a rest position of the trigger switch to a tactile feedback position of the trigger switch;
f. force increases at a second average rate greater than the first average rate in a second range from the tactile feedback position to a maximum position of the trigger switch;
g. the circuit is enabled to output an audio deterrent at a position within the first range spaced respectively from each extreme of the first range; and
h. the canister is opened to release the aerosol in a portion of the second range that is less than the entire second range.

10. A system for spraying comprising:
a. a canister;
b. a shuttle to open the canister in response to movement of the shuttle; and
c. a trigger switch; wherein
d. the shuttle and the trigger switch cooperate with discontinuous mechanical coupling; and
e. the trigger switch provides a discontinuity in bias against operation of the trigger switch by a user before opening the canister to output a spray of the contents of the canister.

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